Prioritized Technology: Small Satellites – Communications

Technical Goal

Reliable low power radiation-hardened Communication Systems for CubeSats and small satellite platforms capable of operating in extreme environments of Venus, Moon, Asteroids/NEOs (Small bodies), Ice Bodies/Ocean Worlds/Outer Planets, and Mars. Communication systems include deployable direct-to-earth systems with rates of tens to hundreds kbps to MBps and provide accurate relative position knowledge for formation flying for spatial and/or temporal measurements that span large distances or in specific regions of interest.

Venus: 1) Direct-to-earth comm systems for low power (~100W) 6U – 12U small sats in a low intensity, corrosive environment to transmit 80Gbits/day with data rate 128kbps with mission life up to 5 years. 2) Low power (<3W) comm system for a surface probe to an on-orbit spacecraft with data rate ~100 kb/s with mission life up to 3000 hours. 3) surface probe direct-to-earth comm system with data rate ~100 kb/s with mission life up 200 hours Surface probes are in high temperature high pressure (450C, 92 bar) environment.

Moon: low power (~90W) comm systems for 1) 12U spacecraft with 1 year mission life, 256 kB/s, 300 MB/day 2) ESPA class spacecraft: 622Mb/s 3) ESPA class, SW defined radio

Mars: low power comm for 6U-12U spacecraft with 4 year mission life 2) UHF link to Mars Orbiters 50 kbps 3) Direct-to-earth comm xx kb/s w 30Wh battery w 4W SA

Small Bodies: Comm system for 1) 90kg spacecraft using 5W laser comm low power 6U spacecraft, 5 year mission life 2) Comm btwn ESPA-size and 4 12U sc 3) Laser Comm from NEA direct to Earth 4) 256 kbps direct to Earth

Icy Bodies/Outer Planets/Ocean Worlds: 1) Rad Hard low power low temp (50W, 240K) direct to earth comm systems for ESPA Class for 5 year cruise, 1 year science 2) Rad Hard low power low temp (50W, 240K) direct to earth comm systems for 30kg Probe for 8 year cruise, 1 year science

Technical Status

Iris: A 'smart' software defined radio(SDR) that is DSN compatible for Direct-to-Earth comm

- Mass: 1 kg (volume 0.5 U)
- Max DC Power: 28W (as tested - full duplex mode)
- TID: 23 krad, LET 37 MeV (rad hard)
- Receiver Frequency: X-band, UHF option available for flight
- Receiver Sensitivity: -151 dBm
- Navigation: Coherent turn around, DOR tones
- Transmit Power: 3.8W RF (end of life)
- Transmit Freq: X-band, Ka-band option available at TRL4
- Encoding: Conv, Reed Solomon, Turbo 1/2, 1/3, 1/6

Moon: 256 kbs, 300 MB/day

Venus: 2.5-5 kbps, 9-18MB/day

Mars: 2-4 kbps, 8-16 MB/day

Small Bodies: 1 kbps, 3.6 MB/day

Icy Bodies/Outer Planets/Ocean Worlds: Would require radio for proximity communication

Assumes: 1) use of X-band MGA (23 dB gain), 2) 8 hour pass/day with DSN

To close the gap between goals and the current capability for the inner solar system, we need:

1) X-band 10-40W SSPA (increases return by up to 8X)
2) Ka-band 10-30W SSPA (increases data return by 24X, assumes use of small HGA)

Mission Applications

Examples of applications include:

Venus: extended exploration (atmospheric and surface) for up to 1 year vs 2 hours with current technology.

Moon: multi-point mapping of lunar surface to understand lunar evolution.

Mars: multi-point, simultaneous measurements of Mars environment; observing the Martian environment over a Martian year, furthering knowledge of Mars' composition, temperature, ion escape/sputtering.

Small Bodies: constellations of probes to multiple small bodies or probes utilized to "point and stare" at a specific small body target.

Icy Bodies/Outer Planets/Ocean Worlds: exploration of outer worlds such as Uranus via Probes or provide multipoint measurements to investigate modes of solar wind coupling in Jupiter as well as neutral atoms escape.